



# A Fuels Strategy to Achieve a Fire Safe Condition at the Placer County Grove of Big Trees

For USDA Forest Service  
Tahoe National Forest  
Foresthill Ranger District  
and  
Washington Institute  
Technical Fire Management 14  
March 2000

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USDA Forest Service



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## EXECUTIVE SUMMARY

The 1990 Mediated Settlement Agreement require that naturally occurring sequoia groves be protected, preserved, and restored to natural conditions. This project analyzes the risk of mortality to the Placer County Grove of Big Trees, Giant Sequoia (*Sequoiadendron giganteum*), from a wildfire event.

The analysis began by defining a project area around the Placer grove. This area was determined as a 140-acre sub-watershed. The collection of data on down woody fuels, weather, fire history, and forest structure to help define existing conditions was conducted. I used Brown's planar Intersect method to collect fuels data to be input into a computer program called DDWoodyPC, this calculated the current fuel loading by size class. Fire scar samples were taken to derive the mean fire return interval. Weather data was extracted from the R5 Weather and Fire Data CD-ROM and assimilated using FireFamily Plus to determine the 50<sup>th</sup> and 90<sup>th</sup> percentile weather. The weather data was input into BEHAVE Fire Behavior Prediction System and Van Wagner's crown initiation formula to determine fire behavior characteristics. FOFEM (First Order Fire Effects Model) was used to determine potential mortality to the stand. A statistical fire risk assessment was estimated using the computer program PROBACRE.

The desired conditions were developed for the Placer grove using Piirto and Roger 1999 "An Ecological Foundation for Management of National Forest Giant Sequoia Ecosystems". Fuels treatment alternatives were developed to bring existing conditions of the grove to desired conditions. An economic analysis of alternatives using the Tahoe National Forest NFMAS data was used to compare, the cost of suppression, the cost of treatment, and NVC to determine the net marginal benefit.

With this data a fuels strategy is recommended to achieve a fire safe condition at the Placer County Grove of Big Trees. The strategy will reduce the dead down woody fuel loading by a minimum of ten tons per acre in the one-inch and greater size classes, and trees less than 4-inch DBH will be reduced from 254 to 60 trees per acre. This reduction is best described as a FBPS fuel model 9, which produces a low intensity fire, and will minimize mortality to the stand. Any further implementation of this analysis would have to be accomplished preparing the appropriate documents, which meet the National Environmental Protection Act (NEPA) requirements.

## INTRODUCTION

The Placer County Grove of Big Trees, Giant Sequoia (*Sequoiadendron giganteum*) is the smallest and the most northern of the natural groves of sequoias in the Sierra Nevada Mountain Range of California, the only state in which they occur naturally. The nearest grove to this is 60 miles to the south in Calaveras County. The Placer County Grove was reported to have been discovered in 1855 by Joe Matlock, a gold prospector. The Placer Grove consists of six mature trees, two fallen trees, and one natural sapling discovered in 1990. In 1928 ten sequoias were planted, in 1949 fifty seedlings were planted and then another thirty five seedlings were planted in 1951, all of these seedlings are not of natural stock. See (Appendix 1.) the individual tree location map. The grove is located on the Foresthill R.D. of the Tahoe N.F. at an elevation of 5,200 feet, and is influenced by a Mediterranean climate.

The grove has been protected since 1892 when the Department of Interior withdrew the entire township from resource and mineral entry. In 1949 the Regional Forester Thompson designated it "Placer County Big Trees Grove Recreation Area." In 1980 the mineral withdrawal of the township was vacated except for the 160-acre grove, and then in 1992 it was increased to 200 acres. Currently the grove is designated as the Placer County Big Trees Botanic Area under 36CFR 294.1 (a) within the Tahoe N.F. Land and Resource Management Plan (TNF LRMP MA 107), where 346 acres are managed. Within the MA 107 are two interpretive trails, restroom facilities, and a picnic area. (Appendix 2.), is a map of the administrative area (MA 107) and the withdrawn area. In 1990 The Mediated Settlement Agreement requires that the sequoia groves be protected, preserved, and restored to natural conditions, and in 1992 President Bush proclaimed, "Naturally occurring old-growth giant sequoia groves are unique national treasures that are being managed for biodiversity, perpetuation of the species, public inspiration, and spiritual aesthetic, recreational, ecological, and scientific values." Among other things, he proclaimed, "The designated giant sequoia groves shall be protected as natural areas with minimum development." The actual grove encompasses only a small portion of the management area. Outside the grove is an old growth stand of mixed conifer, with a productive pair of California spotted owls (*Strix occidentalis occidentalis*). A Protected Activity Center (PAC) was established to comply with the California Spotted Owl Sierran Province Interim Guidelines Environmental Assessment (CASPO). Historical records indicate there was no logging activity within the grove.

With the advent of fire suppression in the early 1900s, fires have been largely excluded from the area in and around the Placer grove. This effective fire suppression activity has altered the forest structure with an accumulation of surface fuels, ladder fuels, and large woody debris. This changed the historical fire regime from one of frequent low intensity fires to one of infrequent, high intensity fires (Swetnam et al. 1992).

## **PROBLEM STATEMENT**

The protection of the Placer County Grove of Big Trees from fire and resource entry has altered the natural fire regime and allowed a fuel buildup in and around the grove. This has placed the grove at a high risk of mortality due to a high intensity fire event.

## **GOAL**

Develop a fuel treatment strategy that will reintroduce fire into the grove and reduce surface fuels, ladder fuels, and fuel accumulations in and around the grove so the trees can survive a wildfire event.

## **OBJECTIVE**

Determine the current fire and fuel characteristics.

Develop and recommend the most cost effective fuels treatment that will prevent mortality to the Placer County Grove of Big Trees in the event of a wildfire.

## **METHODS**

Collect data on down woody fuels, weather, and forest structure to help define existing conditions.

Analyze fire scars to derive fire history.

Determine risk to the grove using computer models and compile existing condition data.

Determine desired condition of grove by working with resource specialists.

Develop a cost revenue analysis to compare alternatives.

## **PHYSICAL DESCRIPTION OF ANALYSIS AREA**

### **Geographical Location**

The Placer County Grove of Big Trees is located north of the Middle Fork of the American River on the Foresthill Ranger District of the Tahoe National Forest. The Legal location is Township 14 North, Range 13 East, Sections 18 and 19 Mount Diablo Base, and Meridian (T.14N., R.13E., Sections 18, 19). The Placer grove is 25 driving miles East of Foresthill just off the Mosquito Ridge Road at an elevation of around 5200

feet. Currently the grove is designated as the Placer County Big Trees Botanic Area under 36CFR 294.1 (a) within the Tahoe N.F. Land and Resource Management Plan (TNF LRMP MA 107), where 346 acres are managed. The project will focus on 140 acres in and around the grove.

## Topography

A broad ridge and a steep canyon oriented northeast and southwest along the Middle Fork of the American River characterize the area. The grove lies on the north side of the river along the ridge top in an intermittent drainage. Slopes range between 10 to 35 percent except on the ridge top where it is relatively flat.

## Soils

Soils consist of four soil series within the Placer grove watershed: Hurlbut, Deadwood, Mariposa, and Jocal. The Placer grove location is on the Mariposa-Jocal complex. Jocal series consists of deep and very deep, well drained soils. Mariposa series are shallow and moderately deep, and have a thin surface layer.

## Vegetative Cover

Overstory vegetation consists of a mature old growth stand of mixed conifer, with the dominant species being sugar pine (*Pinus lambertina*). Ponderosa pine (*Pinus ponderosa*) Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and California black oak (*Quercus kelloggii*) also occupy the overstory, but to a lesser extent. Shade tolerant species of white fir (*Abies concolor*), pacific dogwood (*Cornus nuttallii*), and incense cedar (*Calocedrus decurrens*) occupy the lower portions of the overstory. Without fire naturally thinning the stands, dense thickets of these shade tolerant species have become established. The actual grove encompasses only a small portion of the project area, less than five acres in size. (Appendix 3.), is a vegetation map of the Placer grove.

Understory vegetation consists of dense thickets of shade tolerant conifer species of white fir (*Abies concolor*) and incense cedar (*Calocedrus decurrens*). In opening, reproduction of sugar pine (*Pinus lambertina*) ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) occupy the area. Shrub species of tanoak (*Lithocarpus densiflora echinoides*), greenleaf manzanita (*Arctostaphylos patula*), snowberry (*Symphoricarpos sp*), western azalea (*Rhododendron occidentale*), pinemat manzanita (*Arctostaphylos nevadensis*) and california wild rose (*Rosa californica*) are present, with shrub tanoak occupying the majority of the area.

A forest inventory analysis was conducted, the process described in “Forest Inventory and Analysis User’s Guide” (FIA) (Appendix 4.), and it estimated the project area to have 508 trees per acre, with 65 percent of these trees being white fir.

## Surface Fuels

I conducted a fuels inventory for the dead and down woody material to determine fuel loading, duff depth, and fuel bed depth. See (Appendix 5.), the plot inventory map for the Place grove. The material being sampled was non-slash, so I used a plane length of 35 feet at a randomly selected direction at each plot. Plots were located at a fixed distance of 585 feet laced regularly across the project area. This type of a systematic random sampling method will optimize coverage of the project site (Brown 1974). This field data was entered into a computer program called DDWoodyPC (Version 1.2.8). This computer program is a spreadsheet that uses Brown's computational formulas to calculate the mean, the standard deviation, standard error and percent error of fuel loadings by size class in tons per acre (see Appendix 6.). Table 1 displays the results of the fuels inventory.

**Table 1. Big Trees Dead Down Fuel Loading**

Size class	0 to .24"	.25 to.9"	1 to 2.9"	3 to 6"	6 to 9"	9 to 20"	20 +	Needles	Total (Mean)	S.D	S.E.	%Err
Tons/acre	0.89	2.31	5.52	2.92	5.48	10.96	0.0	.50	28.58	17.39	3.89	13.85

## Ladder Fuels

The ladder fuels act as carriers of the fire if surface intensity levels are at or above the critical level to ignite the foliage. Eighty four percent of the trees (425/acre) in the project area are in the one to nine inch diameter group (1" to 9" DBH). Ladder fuel accumulations of less than four-inch live shrubs and conifers were calculated to provide an estimate of the effects to surface fire flame lengths and intensities needed to ignite the understory foliage and cause a torching effect. The forest inventory analysis (Appendix 4.) indicates a total of 254 trees less than four-inches per acre. Multiplying the number of trees per acre by crown weights using tables from Snells handbook for predicting slash weight of western conifers and dividing by 2000 (conversion factor) provides tons per acre of fuel (Snell 1978). An estimated combustible ladder fuel loading (needles and fine branches) of 2.67 tons per acre are within the project area (Appendix 7.).

## Fuel Modeling

The criteria for choosing a fuel model includes the fact that fire burns in the fuel stratum best conditioned to support fire. Fuel models are simply tools to help the user realistically estimate fire behavior. The user must maintain a flexible frame of mind and an adaptive method of operating to totally utilize these aids. For this reason, the fuel models are described in terms of expected fire behavior and vegetation. There are 13 Fire Behavior Prediction System (FBPS) fuel models that are described by fuel load, fuel bed depth, and the surface area to volume ratio for each size class (Anderson 1982).

Based on the fuels inventory of dead down woody material and the forest inventory analysis the project is best represented by a FBPS fuel model 10. The fires burn in the surface and ground fuels with greater intensity than other timber litter models. Dead-

down fuels include greater quantities of 3-inch or larger limbwood resulting from overmaturity. Crowning out, spotting, and torching of individual trees is more frequent in this fuel situation (Anderson 1982). Table 2 displays a comparison in fuels data collected and FBPS fuel model 10.

**Table 2. Fuel Model Comparison**

Size class	1 hour 0 to .24"	10 hour .25 to .9"	100 hour 1 to 3"	Live	Fuel bed Depth inches
Fuels Inventory T/A	1.39	2.31	5.52	2.67	7.62
FBPS fuel model 10 T/A	3.01	2.00	5.01	2.00	12.00

## Weather

The weather station used for the project area is located on the Georgetown Ranger District of the Eldorado National Forest, at the Bald Mountain Lookout. The National Fire Danger Rating System (NFDRS) number for the station is 042603. I used this station because of its proximity to the project area. This station lies on the south side of the Middle Fork of the American River at an elevation of 4592 feet, 11 miles southwest of the project area. This station also offered over 30 years of historical weather data.

I retrieved the weather data for NFDRS station 042603 from the Fire planner on the Eldorado National Forest (Appendix 8.). The weather data was from the Region 5 Weather and Fire Data CD-ROM (Rev. 2.0, 9/1996).

The data was entered into FireFamilyPlus, Version 1.0.10, February 1999, for analysis. I used 90<sup>th</sup> percentile weather to predict average worse case weather values to define the approximate upper level of fire behavior (Deeming, 1978). To adjust the 20-foot wind speed to a Mid-flame wind speed, I used an adjustment factor of 0.4 because the fuels are high on the ridge where trees offer little shelter from wind (Rothermel, 1983). Table 3 displays a summary of weather output values (fuel moisture, wind speed, temperature, and relative humidity).

**Table 3. Bald Mountain Weather**

Percentile Range	50 <sup>th</sup>	90 <sup>th</sup>
1 Hour FM	6.48	3.67
10 Hour FM	6.00	4.00
100 Hour FM	11.00	6.02
1000 Hour FM	15.38	7.55
Herb FM	103.33	45.04
Woody FM	121.08	56.91
20-foot WS	9.00	12.00
Mid Flame WS	3.60	4.80
Temperature	77.00	86.00
Relative Humidity	43.00	22.00

## Air Quality

Air quality in the Placer Grove of Big Trees is generally very good, due to the elevation and distance from any large metropolitan area. The area is rarely impacted with haze or poor air quality. Occasional impacts occur due to smoke from wildfires and wood fiber waste burns, fugitive dust from logging operations, and recreational activities. These activities are conducted on both public and private land within the area.

The Placer Grove area lies within the boundary of Placer County. Placer County is in a severe non-attainment for ozone as it relates to State and Federal ambient air quality standards established by the Clean Air Act passed in 1963 by the U. S. Congress.

## Fire History

I took five samples from the project area to determine the fire return interval and the number of years the last fire burned. The area had numerous fire scars on the large old growth pines. The fire scar samples were taken from the area surrounding the grove. Sample number one was taken from the southeast side, sample two from the east, sample three from the northwest, sample four from the southwest, and sample five from the west. The area the samples were taken from is approximately 15 acres in size, and the farthest distance between samples is 1500 ft. All the samples were removed with a chainsaw by cutting into the fire scar and removing a cross section of the tree (Arno and Sneek 1977). The samples were sanded with a belt sander to accurately count the growth rings and fire scars. The results are displayed in Table 4.

**Table 4. Point Fire Scar Samples**

Tree 1	Tree 2	Tree 3	Tree 4	Tree 5
1896 fire scar	1896 fire scar	1896 fire scar	1896 fire scar	1895 fire scar
1884 fire scar	1884 fire scar	1884 fire scar	1884 fire scar	1874 fire scar
1874 fire scar	1874 fire scar	1874 fire scar	1874 fire scar	1865 fire scar
1859 fire scar	1859 fire scar	1865 fire scar	1865 fire scar	1851 fire scar
1851 fire scar	1851 fire scar	1859 fire scar	1859 fire scar	1844 fire scar
1844 fire scar	1844 fire scar	1851 fire scar	1851 fire scar	1820 fire scar
1832 fire scar	1832 fire scar	1844 fire scar	1844 fire scar	1804 fire scar
1820 fire scar	1820 fire scar	1832 fire scar	1820 fire scar	1794 fire scar
1794 fire scar	1794 fire scar	1741 pith	1806 fire scar	1784 fire scar
1678 pith	1784 fire scar		1764 fire scar	1750 fire scar
	1778 fire scar		1686 pith	1735 fire scar
	1750 fire scar			1726 fire scar
	1726 fire scar			1711 fire scar
	1630 pith			1632 pith
Mean 12.75	Mean 14.17	Mean 9.14	Mean 14.67	Mean 15.33

The fire scar samples show the last fire to burn in the Placer grove was 103 years ago in 1896. The mean fire return interval for individual point samples ranges from 9.14 years to 15.33 years. An arithmetic average of these over the 15-acre study area is 13.21 years. When the samples were carefully studied it shows many of the fire scars occurred on the same years and others were skipped. The assumption can be made that the fire was not intense enough to make a scar, or that the preceding fire burned away the scar. To correct this and integrate the fire scars to a composite fire interval, I compared the samples to calculate the composite fire return interval (Agee 1993). The composite fire return interval calculated at 10.36 years.

## **FIRE BEHAVIOR CHARACTERISTICS**

### **Surface Fire Behavior**

I used the computer program BEHAVE SYSTEM Burn Subsystem FIRE 1 Program Version 4.4 February 1997, to predict the surface fire rate of spread for a forward moving head fire. Table 5 displays both the input and output values for the surface fire behavior for FBPS fuel model 10 at the 90<sup>th</sup> percentile weather.

**Table 5. Surface Fire Behavior FBPS fuel model 10 (BEHAVE program)**

<b>Input Values</b>	<b>50<sup>th</sup></b>	<b>90<sup>th</sup></b>	<b>Output Values</b>	<b>50<sup>th</sup></b>	<b>90<sup>th</sup></b>
Woody FM	121.08	56.91	Rate of Spread, CH/HR	6	16
1 hr FM	6.5 %	3.7 %	Heat Per Unit Area, BTU/SQFT	1228	1491
10 hr FM	6.0 %	4.0 %	Fireline Intensity, BTU/FT/S	142	424
100 hr FM	11.0 %	6.0 %	Flame Length, FT	4.4	7.3
Mid Flame WS	3.6mph	4.8 mph	Reaction Intensity, BTU/SQFT/M	5643	6849
Slope	35 %	35 %	Effective Wind speed	4.5	5.6

### **Torching, Crowning, and Extreme Fire Behavior**

To incorporate the ladder fuels into the fire behavior and predict mortality to the project area. I needed to analyze the critical surface fire intensity to ignite the understory foliage.

Torching is defined as a sudden envelopment of an entire tree crown. The flames may involve a single tree or a small group. A crown fire is a fire that involves the crowns of trees or shrubs. There are three types of crown fires: passive, active, and independent. A passive crown fire is small scale; this stage reinforces the spread of the fire, but the main spread is still dependent upon surface fire behavior. The active crown fire is associated with a “pulsing” spread and fire spreads in the crowns faster than on the surface. The independent crown fire occurs when conditions are such that fire will run through the crowns without support from an intense surface fire (Van Wagner, 1977).

Van Wagner’s formula (Figure 1) defines the critical level of surface fire intensity needed to ignite the understory foliage and initiate a torching effect. The fireline intensity is the

heat released per second from a one-foot wide section of fuel extending from the front to the rear of the flaming zone (BTU/FT/S).

### Figure 1. Van Wagner's Crown Initiation Equation

$I_s \geq I_o$  = Heat required to ignite crown foliage to ignition temperature. The inverse is also true.

$I_s \leq I_o$  = The heat required to ignite crown foliage will be generated and a surface fire will result.

$I_s$  = Fireline intensity

$I_o$  = Critical surface intensity for initiation of crown combustion

The critical crown combustion computational formula is:

$$I_o = (Czh)^{1.5}$$

Where:  $C$  = constant as .010 (Van Wagner 1977)

$z$  = live crown base

$h$  = heat of ignition ( $460 + 26 \times \text{foliar moisture}$ )

The live crown base height in the 8-inch to 11-inch DBH class trees average 7 feet. This was measured during the FIA and fuels inventory. I used these trees due to their height, and their crowns intermingled with the overstory trees. These trees average 48.4 feet tall and provide the ladder to the overstory trees as well as the giant sequoia (Appendix 7.).

The crown initiation formula was used to calculate the critical surface fire intensity for the Placer grove. I used a 7-foot crown base height (measured), and 100 percent foliar moisture content based on estimations from guides by Rothermel (Rothermel 1983). To convert the formula to English units a conversion factor of .28909 was used. Figure 2 displays the critical surface fire intensity to initiate a torching effect.

### Figure 2. Placer Grove Critical Surface Fire Intensity

$$(.010 \times 2.134(460 + 26 \times 100))^{1.5} = 527.684 \text{ kw/m}$$

$$527.684 \times .28909 = 152.548 \text{ Btu/ft/s}$$

The fire intensity ( $I_s$ ), calculated by the BEHAVE program, is 142 Btu/ft/s at the 50<sup>th</sup> percentile weather, and 424 Btu/ft/s at the 90<sup>th</sup> percentile weather. Figure 2 shows the critical surface fire intensity to initiate a torching effect is 152.548 Btu/ft/s. The critical level is clearly exceeded at the 90<sup>th</sup> percentile weather.

$$I_s \geq I_o = 424 \text{ Btu/ft/s} > 152.548 \text{ Btu/ft/s}$$

## Mortality and Fire Effects

To determine the mortality to the trees within the stand, I used the computer-modeling program “First Order Fire Effects” version IV (FOFEM) (Reinhardt, Keene, Brown 1997) and the FIA data. This program uses flame length or scorch heights to model tree mortality, fuel consumption, soil exposure, and smoke production. Flame length as predicted by BEHAVE and the FIA data as well as the number of trees per acre by species was used to determine the mortality to the stand in the project area. This program only uses the surface fire flame length without the torching effect. Figure 3 displays the results of mortality to the stand. The FOFEM run is in (Appendix 9.).

### Figure 3 Mortality by Flame Length

*The original stand density from the FIA data (Appendix 4.), as input to FOFEM.*

<i>Total Number of Trees per Acre</i>														
<i>DBH classes (in.)</i>														
<i>DBH</i>	<i>2</i>	<i>4</i>	<i>6</i>	<i>8</i>	<i>10</i>	<i>12</i>	<i>14</i>	<i>16</i>	<i>18</i>	<i>20</i>	<i>22</i>	<i>24</i>	<i>26</i>	<i>28+</i>
<i>Totals</i>	<i>40</i>	<i>214</i>	<i>112</i>	<i>40</i>	<i>19</i>	<i>24</i>	<i>14</i>	<i>14</i>	<i>5</i>	<i>2</i>	<i>3</i>	<i>2</i>	<i>2</i>	<i>17</i>

  

<i>Post Fire Stand Density 7.3 foot Flame Length</i>														
<i>DBH</i>	<i>2</i>	<i>4</i>	<i>6</i>	<i>8</i>	<i>10</i>	<i>12</i>	<i>14</i>	<i>16</i>	<i>18</i>	<i>20</i>	<i>22</i>	<i>24</i>	<i>26</i>	<i>28+</i>
<i>Totals</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>4</i>	<i>4</i>	<i>2</i>	<i>2</i>	<i>2</i>	<i>2</i>	<i>17</i>

Mortality Indexes:

Average Probability of mortality = 93 %

Average Diameter Killed = 5.85 DBH

Number of Trees Killed = 472 trees

Prefire Number of Trees = 508 trees

Average Probability of Mortality for Trees 4+in DBH = 85%

## Probability of a Fire Intrusion

Statistical fire risk analysis was accomplished using the computer program PROBACRE version 1.1 (Wiitala 1992), which uses the Poisson distribution to calculate the probability of an event occurring over time. PROBACRE was used to predict the probability of a fire event affecting the Placer grove. In this case, the number of fire starts exceeding a given size in a specified time frame.

An analysis of the fire history on the Foresthill Ranger District was accomplished using data taken from the National Fire Management Analysis System (NFMAS) for Fire Management Zone 01 (FMAZ 01). The Placer grove lies within the FMAZ 01. I researched the data to determine the total number of fires per year for lightning and human caused fires from 1970 to 1996. (Appendix 10.), displays the number of fire occurrences by size class and cause. The total number of fires was 256 with 64 percent

being lightning caused and 36 percent human caused, with an annual occurrence of 9.85. Fire sizes for FIL 3, 4, and 5 were determined because these fire intensity levels would result in mortality to the stand. Table 6 displays Fire Intensity Level and associated flame lengths.

**Table 6. Fire Intensity Levels and Associated Flame Lengths**

FIL 1	0 – 2 feet
FIL 2	2 – 4 feet
FIL 3	4 – 6 feet
FIL 4	6 – 8 feet
FIL 5	8 – 12 feet
FIL 6	> 12 feet

To further break down the fire history for the Placer grove, I used the District Fire Atlas and the 5100-29 Individual fire reports for the End of the World Watershed from 1960 to 1999. I used this watershed to take into account the fires, which potentially could enter the project area. A total of 28 fires occurred in the watershed with 68 percent being caused by lightning and 32 percent human caused. Table 6 displays the annual fire frequency for the area.

**Table 7. Annual fire frequency for the Placer Grove area 1960 to 1999**

Type	# of fires	% of total	Annual average
Lightning	19	68 %	.487
Human	9	32 %	.231
Totals	28	100 %	.718

The methodology for using the NFMAS data and incorporating it with the annual fire frequency for the Placer grove is taken from the Technical Fire Management (TFM) final project of Robin Scott Abrams. I used the Suppression table 1 MEL –20 from the Tahoe National Forest NFMAS data at the 90<sup>th</sup> percentile weather Representative Location 5 (Appendix 11.) multiplied by the annual average frequency .718 to obtain an annual average frequency, and the final size of escaped fires, as inputs into the PROBACRE program. Table 8 displays this formula.

**Table 8. Predicted annual fire frequency by FIL**

FIL	Annual Ave		FMAZ 01 Ratio by FIL		Predicted Fires / Year	Escaped Fire size in acres
3	.718	X	.123	=	.088	1.75
4	.718	X	.020	=	.014	85.72
5	.718	X	.006	=	.004	3499

The final escaped fire size and the annual frequency were inputs into PROBACRE over specific time periods of 10, 20 and 40 years. Acreage thresholds of 10 percent, 50 percent, and the total analysis area (140 acres) were used. The results are displayed in Table 9 and (Appendix 12.) the PROBACRE runs.

**Table 9. PROBACRE Results**

Acreage Thresholds	10 years	20 years	40 years
14 acres	16%	30%	53 %
70 acres	16%	30%	51%
140 acres	5%	11%	24%

The data indicates a twenty four percent probability that cumulative fires will exceed the 140-acre, or the total project area in forty years.

## **Conclusion of Fire Behavior Characteristics**

The data indicates fire behavior characteristics at current conditions are too intense and will cause a torching effect to the stand. Trees less than twenty-two inches diameter breast height (4 ½ feet) will experience mortality, and trees less than ten inches DBH will have 100 percent mortality. The mortality to trees is based on a 7.3-foot flame length without any torching of ladder fuels. This under estimates the mortality of the larger trees, due to a torching effect. Fire intensities at or above 152.548 Btu/ft/s will cause a torching effect. The BEHAVE program predicted fire intensities at 424 Btu/ft/s at the 90<sup>th</sup> percentile weather. The probability of fire intrusions where the total project area (140 acres) will burn is twenty four percent in forty years.

## **DESIRED CONDITION**

The desired condition for the Placer County Grove of Big Trees is that of “old growth”, “ancient forest”, or “late seral stage” character. The vegetative pattern is made up of a variety of gaps and patches. The boundaries of gaps and patches are characterized as being diffuse, often without sharp edges. This mosaic pattern is an important attribute of the grove (Piiro and Rogers 1999). Piiro and Rogers report that this mosaic pattern is caused by fire disturbance. These fires were frequent, low intensity fires with a return interval of 5 to 20 years that consumed much of the debris on the forest floor and killed the shrubs and sapling trees, but rarely ignited crowns of larger trees. Occasionally some patches (typically less than ½ acre) burned hot enough to kill some or all the larger trees. This frequency would produce a forest floor with a shallow layer of duff over the soil, and open, barren patches where seeds of shade intolerant plants such as ponderosa pine, giant sequoia, shrubs, and grasses could germinate and grow.

Another observation of the project area was made in 1901, by John B. Leiberg while conducting surveys of the Northern Sierra Nevada Mountain Range for the U.S. Geological survey (Leiberg 1902). His accounts and writings in a document to the House of Representatives in 1902 suggest a stand of old growth timber with uneven blocks of timber in various younger age classes due to fires. Leiberg wrote, "The trees are not set closely, averaging 30 to 55 trees of mill size per acre. On the northern slopes trees are tall, of medium diametrical dimensions, but of poor quality, owing to the fire marks. In the Duncan drainage the forest has been so extensively burned that the stands are extremely uneven, they occur in blocks, mostly of small extent, separated by narrow lanes of brush or thinly scattered dense masses of undergrowth."

Natural fuels that produce a low intensity fire can best be described as a FBPS fuel model 9 (timber litter). Piirto and Rogers recommends fuel-loading weights of the dead downed woody material to be between 10 and 18 tons per acre. Trees less than 4 inches DBH should have a maximum number of 60 trees per acre. Figure 4 shows Piirto and Rogers recommendations.

**Figure 4. Piirto and Rodgers Recommendations**

<u><i>Dead fuels by size and amount.</i></u>	<u><i>Live vegetation by size and amount.</i></u>
<i>0 to 1" = 1 - 2 tons / acre maximum</i>	<i>trees &lt; 4" DBH = 60 trees / acre</i>
<i>1 to 3" = 1 - 3 tons / acre maximum</i>	<i>trees 5 to 10" DBH = 40 trees / acre</i>
<i>3 to 9" = 1 - 3 tons / acre maximum</i>	<i>trees 11 to 14" DBH = 25 trees / acre</i>
<i>&gt; 9" = 10 tons / acre (caspo min)</i>	<i>trees 15 to 20" DBH = 15 trees / acre</i>
	<i>trees 21 to 28" DBH = 10 trees / acre</i>
	<i>trees 29 to 38" DBH = 6 trees / acre</i>
	<i>trees 39 to 96" DBH = 4 trees / acre</i>
	<i>trees &gt; 96" DBH = 1 tree / acre</i>
<hr/> <i>Totals 10 – 18 tons / acre (+ 15 tons / acre forest floor max)</i>	<hr/> <i>Totals 161 trees / acre</i>

Note: A maximum of 15 tons / acre (or a depth of 2.5") is the desired forest floor fuel loading. This approximates the natural accumulation of organic material on the forest floor 10 to 20 years after a surface fire (Weise 1996).

To achieve the desired condition for the Placer Co. Grove of Big Trees, a reduction in the dead down woody fuel loading and the number of trees per acre by DBH will need to be accomplished. This will reduce the fire behavior and allow a low intensity fire to burn. Fire intensity levels less than 152.548 Btu/ft/s will remain a surface fire and minimize mortality to the stand. A FBPS fuel model 9 is represented with a range of fuel loading from 3.5 to 10 tons per acre (Blonski and Schramel 1981, Anderson 1982). The majority of the fuel loading is in the less than 3-inch size class. Trees less than 4-inch DBH will need to be reduced from 254 to 60 trees per acre. This will reduce the combustible ladder fuels. Table 10 displays the fire behavior for a FBPS fuel model 9.

**Table 10. Fire Behavior FBPS fuel model 9 (BEHAVE program)**

<b>Input Values</b>	<b>50<sup>th</sup></b>	<b>90<sup>th</sup></b>	<b>Output Values</b>	<b>50<sup>th</sup></b>	<b>90<sup>th</sup></b>
Woody FM	121.08	56.91	Rate of Spread, CH/HR	7	12
1 hr FM	6.5 %	3.7 %	Heat Per Unit Area, BTU/SQFT	362	425
10 hr FM	6.0 %	4.0 %	Fireline Intensity, BTU/FT/S	44	96
100 hr FM	11.0 %	6.0 %	Flame Length, FT	2.6	3.7
Mid Flame WS	3.6 mph	4.8 mph	Reaction Intensity, BTU/SQFT/M	2341	2750
Slope	35 %	35 %	Effective Wind speed	4.3	5.4

The fire behavior for a FBPS fuel model 9 at the 90<sup>th</sup> percentile weather is that of a surface fire. The intensity level to initiate a torching effect is less than 152.548 Btu/ft/s. The actual fire intensity level is 96 Btu/ ft/s; this is well below the fire intensity level needed to ignite the foliage of the understory. Concentrations of dead-down woody material will contribute to possible torching of individual trees (Anderson 1982).

## **FUELS TREATMENT ALTERNATIVES**

The following treatment alternatives will be analyzed.

1. No Action
2. Mechanical Treatment
3. Prescribed Burning
4. Prescribed Burning with Pre-Treatment

### **No Action**

This alternative complies with the Code of Federal Regulations 40 CFR 1502.14(d) and the National Environmental Policy Act, which requires a no action alternative to be included in the analysis. Current activities within the analysis area would continue.

### **Mechanical Treatment**

This alternative was considered but dropped from the analysis due to the classification of the Placer Co. Grove of Big Trees as a botanical area, as outlined in FSM 2361 and pursuant to 36 CFR 294.1(a). Areas should be managed in their natural condition, and

approval of certain uses, or management practices will be approved by the Chief of the Forest Service or by officers he may designate. If a designation change, or a long-term management plan is implemented, this alternative will be reconsidered.

### **Prescribed Burning**

This alternative uses prescribed burning to meet the desired condition for the Placer grove. A low intensity prescribed fire would be applied to the project area to reduce the dead-down woody fuel and ladder fuel. To meet the desired condition for the Placer grove two entries may be needed due to the fuels left standing after the initial prescribed burn. A prescribed fire burn plan would be developed prior to any underburning.

### **Prescribed Burning with Pre-Treatment**

This alternative will have a pre-treatment strategy prior to prescribed burning. The pre-treatment strategy will consist of the use of chainsaws cutting out ladder fuels from the base of the sequoia trees and other trees at risk, thinning dense pockets of reproduction, pruning, and brushing to keep mortality of trees to a minimum. Fuels treated will be spread out over the area to minimize large concentrations of fuels, and prevent torching. A prescribed fire burn plan would be developed prior to any underburning.

## **Economic Analysis of Alternatives**

An economic comparison of the current management (Existing Condition) and implementing the recommended fuels strategy (Desired Condition) is made in this section. The expected cost of suppression and the net value change to resources (C+NVC) under the alternatives is calculated to determine the net marginal benefits. Suppression costs and net value change to resource by FIL in FMAZ 01 from NFMA is displayed in table 11, and table 12.

**Table 11. Suppression Cost per Acre for FMAZ 01**

<b>Upper Acre Limit</b>	<b>Cost / Acre</b>
0.25 acres	\$9297
10 acres	\$5709
100 acres	\$2178
300 acres	\$1777
1000 acres	\$1284
5000 acres	\$601
5000 + acres	\$516

**Table 12. NVC by FIL per Acre in FMAZ 01 for Mixed Conifer**

<b>Resource</b>	<b><i>FIL-1</i></b>	<b><i>FIL-2</i></b>	<b><i>FIL-3</i></b>	<b><i>FIL-4</i></b>	<b><i>FIL-5</i></b>	<b><i>FIL-6</i></b>
Mature Timber	-767.99	-1309.58	-1525.03	-1648.41	-1221.04	-1221.04
Immature	-55.25	-100.14	-138.12	-138.12	-138.12	-138.12
Saplings	-46.91	-76.25	-84.60	-84.60	-84.60	-84.60
Forage	0.01	0.09	0	-0.03	-0.05	-0.11
Water Use	9.67	19.33	28.31	37.97	47.64	66.97
Water storage	-3.27	-6.53	-9.92	-9.92	-16.46	-16.46
Fish	-11.34	-11.34	-11.34	-11.34	-39.54	-39.54
Wildlife Big Gm	0	0	0.47	-1.56	-1.88	-2.34
Wildlife Other	0	0	1.62	-5.39	-6.46	-8.08
Recreation	0	0	-41.86	-129.03	-219.79	-306.96
Wilderness	0	0	0	0	0	0
Improvements	0	0	0	0	0	0
<b>TOTALS</b>	<b>-875.08</b>	<b>-1484.42</b>	<b>-1780.47</b>	<b>-1990.43</b>	<b>-1680.30</b>	<b>-1757.63</b>

Note: Negative means loss.

Using the 90<sup>th</sup> percentile weather for a FBPS fuel Model 10, BEHAVE calculations, it was estimated a fire burning under current conditions would have 7.3-foot flame length and fire intensity levels of 424 Btu/ft/s. This indicates a FIL-4, for the current conditions. The desired condition is represented by a FIL-2 (Table 9.). The average escape fire size in acres for the FIL-4 is 85.72 acres, and for FIL-2 are 4.37 acres (Appendix 11.). Figure 5 compares the suppression costs and net value change to resources by FIL.

### **Figure 5. Suppression Cost and NVC by FIL**

#### **FIL-2**

$$NVC = \$1484.42 \times 4.37 \text{ ac} = \$6,486.92$$

$$\text{Suppression Costs} = \$5709.00 \times 4.37 \text{ ac} = \$24,948.33$$

$$\text{Total} = \$31,435.25$$

#### **FIL-4**

$$NVC = \$1990.43 \times 85.72 \text{ ac} = \$170,619.66$$

$$\text{Suppression Costs} = \$2178 \times 85.72 = \$186,698.16$$

$$\text{Total} = \$357,317.82$$

The cost per acre for fuel treatment alternatives is based on district fuels and silviculture contracts. The cost for prescribed burning is \$125 per acre, and the cost for prescribed burning with pre-treatment is \$425 per acre. The total cost for each fuels treatment alternative is displayed in figure 6.

### **Figure 6. Cost for Fuels Treatment Alternatives**

#### **Prescribe Burn**

*\$125/acre x 140 acres = \$17,500.00 for treatment.*

#### **Prescribe Burn with Pre-Treatment**

*\$425/acre x 140 acres = \$59,500.00 for treatment.*

Table 13 displays the comparison of maintaining the current management, the no action alternative to the two fuels treatment alternatives. It summarizes predicted fire intensity levels, acres burned, cost of suppression, cost of treatment, and NVC to determine the net marginal benefit.

**Table 13. Comparison of Alternatives**

	<b>No Action</b>	<b>Rx Burn</b>	<b>Rx Burn/Treatment</b>
<b>FIL</b>	4	2	2
<b>Fire Size (ac)</b>	85.72	4.37	4.37
<b>NVC</b>	\$170,619.66	\$6,486.92	\$6,486.92
<b>Suppression Costs</b>	\$186,698.16	\$24,948.33	\$24,948.33
<b>C + NVC</b>	\$357,317.82	\$31,435.25	\$31,435.25
<b>Treatment Costs</b>	\$0	\$17,500.00	\$59,500.00
<b>Total Cost + Loss</b>	\$357,317.82	\$48,935.25	\$90,935.25
<b>Net Marginal Benefit</b>	<b>\$0</b>	<b>\$308,382.57</b>	<b>\$266,382.57</b>

## **CONCLUSIONS**

The study shows that the current fuels conditions at the Placer County Grove of Big Trees has placed it at risk of mortality from a wildfire event. The Placer grove is at a twenty four percent risk of fire intrusions within forty years where the total project area will burn. The fire behavior characteristics at the 90<sup>th</sup> percentile weather condition will be too intense, and will cause a torching effect to the stand. Based on a 7.3-foot flame length, the fire will cause ninety three percent mortality to the stand. The net marginal benefit for the two treatment alternatives is; \$308,382.57 for prescribed burning, and \$266,382.57 for prescribed burning with pre-treatment.

To achieve the desired condition for the Placer Co. Grove of Big Trees, a reduction in the dead down woody fuel loading, and the number of trees per acre by DBH will need to be accomplished. As this analysis has outlined fire behavior characteristics at the 90<sup>th</sup>

percentile weather condition with a fire intensity of less than 152.548 Btu/ft/s and flame lengths of four feet or less would be required. The dead down woody fuel loading will need to be reduced by a minimum of ten tons per acre in the one-inch and greater size classes, and trees < 4" DBH will be reduced from 254 to 60 trees per acre. This reduction is best described as a FBPS fuel model 9 (Table 9.).

Implementation of the fuels treatment alternatives will allow the Placer grove to withstand a wildfire event and bring the area to desired conditions. A prescribed fire burn plan would be developed prior to any underburning.

## **Recommendations**

The analysis outlined four alternatives for consideration, the No Action, Mechanical Treatment, Prescribed Burning, and Prescribed Burning with Pre-Treatment. The Mechanical Treatment alternative was dropped from the analysis due to the classification of the Placer Co. Grove of Big Trees. The other three were analyzed.

The No Action Alternative leaves the Placer Co. Grove of Big Trees at risk of mortality from a wildfire event.

The Prescribed Burning Alternative will offer the highest net marginal benefit, however, it may require an additional treatment at \$17,500.00 to reduce the fuels left standing after the initial prescribed burn.

The Prescribed Burning with Pre-Treatment is the preferred alternative. The net marginal benefit is \$42,000 less than the Prescribed Burning Alternative, however, this treatment will minimize the risk to the sequoia trees, be more aesthetically pleasing to the forest visitors, and be accomplished with one entry.

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## ACKNOWLEDGEMENTS

I would like to thank the following individuals for their support and help towards the completion of this project.

Anna Payne	My wife, Nevada City R.D. Fire Prevention Technician
Howard Carlson	West Zone Fire Management Officer
Ray Hermit	Tahoe National Forest Fire Planner
Gail Parn	Foresthill Ranger District Silviculturist
Christie Neill	Eldorado N.F. Fire Planner
Allen Doerr	GIS coordinator for the Tahoe National Forest
Carol Kennedy	Soil Scientist for the Tahoe National Forest
Matt Triggs	Foresthill R.D. Wildlife Biologist
Chuck Murphy	Foresthill R.D. Forestry Technician
Rich Herrera	Foresthill R.D. Fuels Technician / Handcrew Captain
Harlan Hamburger	Public Service Officer for the Foresthill R.D.
Rich Johnson	Foresthill District Ranger